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ABSTRACT

A computer-integrated manufacturing (CIM) technician program was developed to provide training and technical assistance to meet the needs of business and industry in the face of the demands of high technology. The Computer and Automated Systems Association (CASA) of the Society of Manufacturing Engineers provided the incentive and guidelines throughout the program development process. The first step in the CIM program planning was to determine objectives and establish instructional parameters. In the initial program design were blended together (1) the CASA guide to CIM, known as the "CIM Wheel," which depicts the basic model of a CIM system as it would actually function in industry; (2) the present stage of CIM development in area industries; and (3) the resources and expertise in computer manufacturing already developed at Moraine Park Technical Institute (MPTI) in Wisconsin. Courses were developed around identified competencies and categorized as occupational specific, occupational support, technical support, and general education courses. These computer manufacturing subsystems already available at MPTI were identified as requiring further development and integration: computer-aided design, automated machining and computer-assisted programming, automated material handling and robotics, and manufacturing control and planning. (An addendum provides descriptions of 14 CIM technician courses.) (YLB)

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IMPLEMENTING
COMPUTER INTEGRATED MANUFACTURING
TECHNICIAN PROGRAM

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IMPLEMENTING A COMPUTER INTEGRATED MANUFACTURING TECHNICIAN PROGRAM

BY
ROGER GIBBONS

The use of computers in manufacturing has increased steadily from the early 1950's. The first computers used were mainframes utilizing punch card data entry. The development of the minicomputer and the super mini's along with the reduced cost of computer hardware and the development of powerful application software packages has led to a dramatic increase in the use of computers in manufacturing in the last decade. The microcomputer found its way into computer manufacturing in the early 1980's. As the application software is adapted to and developed for the microcomputer, and the mini and super minicomputers become more powerful and hardware costs decrease, the 1990's will see the computer in ever increasing use in manufacturing.

FACTORY OF THE FUTURE-COMPUTER MANUFACTURING

The use of computers is found in almost all areas of manufacturing today. Modular subsystems controlled by computers perform the following functions:

1. Product Design: Done interactively by a design engineer, specifies the design concepts in a natural way, using a computer that stores data on models; computes the optimal design for different options; displays the results for approval; and allows efficient iteration of this process.

2. Production Planning: An optimized plan for the manufacturing process that includes routing, timing, workstations and operating conditions. The plan is generated by a computer on the basis of product design outputs, scheduling and line balancing, and varying conditions of purchase part deliveries, available resources, product mix, and priorities.

3. Part forming by workstations, each controlled by a small computer, that load and unload pieces, make the parts, employ adaptive control, and incorporate diagnostic devices such as tool-wear and tool-breakage sensors.

4. Material handling by different computer-controlled devices (such as forklifts, warehousing stacker cranes, carts, conveyors, and industrial robots) that handle, store, retrieve, find, acquire, transport, load and unload parts, fixtures and other materials throughout the plant.

5. Assembly of parts and subassemblies at computer-controlled workstations, each of which includes industrial robots with or without sensors, parts presenters and other devices.

6. Inspection of parts, subassemblies and assemblies by computer controlled sensor systems during the manufacturing process and at the end of the process.

7. Information and control via a distributed computer system that stores, processes, and interprets all the manufacturing data, including orders; inventories of materials, tools, parts, and products; manufacturing planning and monitoring; plant maintenance; and other plant activities.

The use of computers in U.S. manufacturing plants has led to dramatic improvements in productivity and quality. If U.S. manufacturing firms are to become formidable international competitors in manufacturing, they must move to computer INTEGRATED manufacturing, or "CIM".

COMPUTER INTEGRATED MANUFACTURING-A DEFINITION

A truly integrated CAD/CAM or CIM system provides computer assistance to all business functions from entry of an order through every step in the process to shipment of the finished product. Implementation of CIM results in the interface of the modular subsystems and results in the automation of the information flow in such a manner that the output of one system serves as the input to another.

For example, at the business planning and support level, a customer order servicing system receives input from the sales force relating to descriptions of products to be purchased by prospective customers. The product description serves as an output to the engineering design function. If the product contains previously designed components, a computer assisted drafting system would output the engineering drawing information to the bill of materials processor and process planning system. If the product description contains new components, the description would serve as input to a computer aided design system where the interactive graphics could be used as a design aid to produce engineering and manufacturing information. The product design database is accessed and further processed to perform the other manufacturing functions necessary to produce the product.

THE BENEFITS OF CIM

Companies that achieve integration of the whole production and marketing process have the best chance of succeeding at home and meeting foreign competition. The benefits of CIM are:

1. Improved product quality due to reduction in human errors and variability through automatic inspection, control and production; lower product liability risk and warranty costs.

2. Lower product cost via labor and equipment productivity improvements, production redesign for manufacturability, energy conservation and material inventory reduction through the improved monitoring and control systems.

3. Timeliness of product delivery accomplished by shorter lead times for product and tooling design, shorter set-up periods possible through programmable machine tools and just-in-time manufacturing methods.

The improved information flow results from total integration will improve the productivity of indirect labor by reducing redundant information collecting, increasing efficiency in data collection and dissemination systems, standardizing data requirements, and improving planning and monitoring functions. Direct labor will also benefit from integration through more efficient use of engineers, reduction in drafting personnel, less shop workers to produce and assemble products, more effective management through more timely and better information. Equipment productivity improvements will result from better utilization of machines through improved monitoring, control and diagnostics, application of group technology to increase batch size and reduce set-up time, longer equipment life due to programmability and improved return on investments.

ASSISTING IN THE TRANSITION TO CIM

Computer integrated manufacturing is imperative for the maintenance and recovery of competitiveness by U.S. manufacturers in domestic and world markets. Companies that aren't adopting CIM may well find themselves losing ground to competitors who are. In order to be responsive to the needs of business and industry as they make the transition from conventional manufacturing to computer integrated manufacturing, it is necessary that technical educators determine objectives for providing instruction and training in the area of computer integrated manufacturing. There will be no factory of the future without technicians of the future. Technical schools must have a mission statement that clearly states a commitment to economic development and assistance to business and industry in providing training and technical assistance to meet the needs of business and industry in the face of the demands of "high technology". In order to provide this assistance to business and industry, it will be necessary for educational institutions to build on present programs, resources, expertise, hardware, and software that will bring us up-to-date with the current state-of-the-art in computer integrated manufacturing. It is in this spirit that the computer integrated manufacturing technician program was developed in the Moraine Vocational, Technical and Adult Education District.

CIM TECHNICIAN PROGRAM DEVELOPMENT

The CIM Technician program was first conceived in 1982, when two Moraine Park staff members attended an Autofact conference and exposition sponsored by the Computer and Automated Systems Association of the Society of Manufacturing Engineers. CASA has provided the incentive and the guidelines throughout the program development process. CASA/SME, which celebrates its 10th anniversary this year, was founded to provide comprehensive and integrated coverage of computers and automation for the advancement of manufacturing. One of CASA's major objectives is to provide liaison among industry, government and education to identify areas where technology development in manufacturing is needed and encourage the development of the totally integrated manufacturing facility.

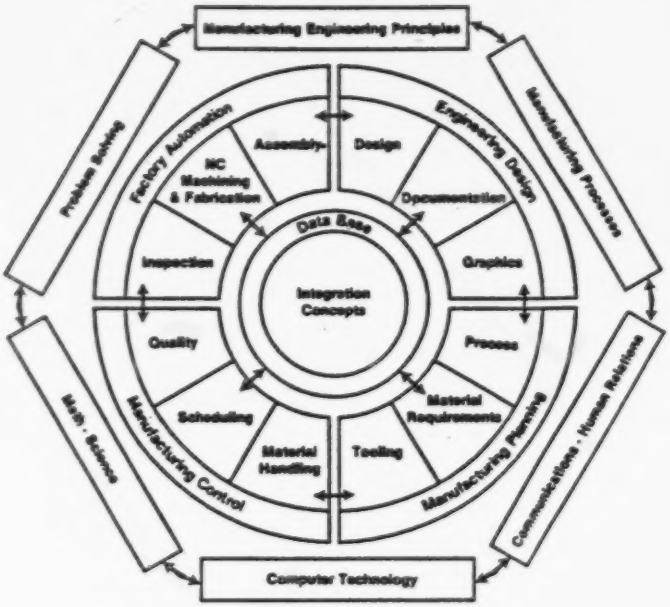
CASA has developed a guide to computer integrated manufacturing known as the "CIM Wheel". The CIM Wheel depicts the basic model of a CIM system as it would actually function in industry. The basic model is flexible enough to allow for changes to accommodate a company's particular total integration plan.

CASA CIM WHEEL

The wheel develops from the inside out. The hub, Integrated Systems, is built upon architecture and common data as a starting point for true integration. The clockwise movement from the top of the circle follows closely the "Order Receipt to Shipment Cycle" found in many companies, and the arrows show the interrelations among the departments and technologies occurring in many companies. Four major areas of manufacturing are identified: Engineering Design, Manufacturing Planning, Manufacturing Control and Factory Automation.

PROGRAM OBJECTIVES: The first step in the CIM program planning was to determine objectives and establish instructional parameters. This was accomplished by Moraine Park staff working with people from the manufacturing community. The CASA guide to computer integrated manufacturing, the present stage of CIM development in area industries, and the resources and expertise in computer manufacturing already developed at Moraine Park were blended together in the initial program design. This design is depicted by the MPTI CIM Wheel.

MPII CIM WHEEL



The similarity of the Moraine Park Wheel to the CASA Wheel is evident. The four major manufacturing areas, Engineering Design, Manufacturing Planning and Control and Factory Automation, were retained, however, some different segments were identified within the four areas. The center or the hub of the wheel emphasizes the common database and the interface of integration concepts. The outer rim of the wheel identifies instruction that supports the occupational core.

CURRICULUM DEVELOPMENT: The first step in developing the curriculum was to identify specific general areas of competency and specific broad competencies. This was done through the DACUM process by an Ad Hoc committee. Competencies were listed for each area identified in the MPTI CIM Wheel. The competencies were then rated according to relevance and importance to the occupation. The courses were then developed around the identified competencies following the guidelines for program development set forth by the State Board of Vocational, Technical and Adult Education. The resulting courses in the curriculum are categorized as follows:

OCCUPATIONAL SPECIFIC COURSES

ENGINEERING DESIGN

616-140	Computer Aided Design & Drafting (3 cr.)
606-175	Computer Aided Design & Manufacturing (3 cr.)

MANUFACTURING PLANNING & CONTROL

628-122	Manufacturing Planning (2 cr.)
628-136	Quality & Process Control (3 cr.)
628-123	Manufacturing Control (3 cr.)

FACTORY AUTOMATION

623-142	Basic Numerical Control (3 cr.)
628-130	Computer Aided Mfg.-Machining (3 cr.)
628-133	Robotics & Automated Material Handling (3 cr.)
628-140	Flexible Manufacturing Systems (3 cr.)

OCCUPATIONAL SUPPORT COURSES

628-110	Computer Integrated Mfg. Concepts (3 cr.)
420-160	Mfg. Processes-Machining (2 cr.)
442-160	Mfg. Processes-Welding/Fabrication (2 cr.)
628-112	Computer Integrated Mfg. Problems (3 cr.)

TECHNICAL SUPPORT COURSES

804-xxx	Technical Mathematics 1, 2, 3 (9 cr.)
806-155	Technical Physics (3 cr.)
628-125	Computer Technology (3 cr.)

GENERAL EDUCATION COURSES

801-151	Communications Skills 1 (3 cr.)
801-152	Communications Skills 2 (3 cr.) (OR)
801-163	Technical Report Writing (3 cr.)
809-110	Economics (3 cr.)
809-153	American Institutions (3 cr.)
809-151	Psychology of Human Relations (3 cr.)

RESOURCE REQUIREMENTS FOR CIM INSTRUCTION

The greatest challenge to implementing a CIM Technician program is to provide the computer hardware and software and equipment necessary to provide meaningful learning experiences that satisfy the course objectives. Moraine Park is fortunate to have developed computer manufacturing subsystems where equipment, computer hardware and software, and instructor expertise already exist. What is needed now is to further develop each subsystem that are totally or partially computerized and to effect a gradual interface of these subsystems to form a totally integrated system.

COMPUTER AIDED DESIGN (CAD): An interactive computer graphics system is essential for CIM program instruction. The system should have application software for 2-D and 3-D design. The system should be configured with a central processing unit that has ample storage for files in order to handle a sizeable database.

The cost of hardware, licenses and maintenance limit the number of workstations that can be provided by a school. Additional lower cost CAD stations can be provided using microcomputers. There are a number of CAD application software packages available. A stand-alone interactive computer system for 2-D design can be put together for under $8,000. The present trend of major CAD/CAM system vendors is to write their software to run on a microcomputer. This will provide for lower cost workstations that can be interfaced with the CPU of a CAD/CAM system.

AUTOMATED MACHINING AND COMPUTER ASSISTED PROGRAMMING: A variety of CNC and programmable machine tools should be used for instruction for part forming and fabricating. This could include horizontal and vertical mills and machining centers, lathes, and fabrication equipment for NC punching and computer controlled cutting.

Essential for instruction in this area is computer hardware and software for program editing, NC graphics, programming, post-processing and distributive NC. Various turn-key systems are available for computer programming. Also, microcomputer based systems are now available that are user friendly and support functions such as NC graphics, post-processing, printing, plotting, tape punching and DNC.

The opportunity to integrate this subsystem with engineering design exists by providing a link to the CAD/CAM database. This would require CAM software to generate cutter location files directly from the piece part design graphics. The files are stored in the graphics system CPU and accessed by the NC department, post-processed and distributed to the corresponding computer controlled machine.

AUTOMATED MATERIAL HANDLING AND ROBOTICS: A starting point to provide instructional equipment in this area is with robots. Specifically, three classifications of industrial robots can be used to teach a variety of applications and programming. Pick and place robots are the least expensive. They can be used for assembly of parts, machine loading and packaging. Multi-axis articulating robots have a broad range of applications from material processing to use in flexible manufacturing systems. These robots can be interfaced with other equipment to control and sequence operations in a system. Robots equipped with sensors and artificial intelligence are used for automated inspection and complex assembly applications.

MANUFACTURING CONTROL AND PLANNING: A typical inspection and reporting system would use a coordinate measuring machine for inspecting parts. Computer assistance to this machine will record, synthesize and report data and can integrate this information with the manufacturing database. Software packages have been developed for statistical process control charting and reporting.

A variety of software packages are available for computer assisted process planning (CAPP) and materials requirements planning (MRP). This software will run on most micro and minicomputer hardware. Much of this equipment is available in most schools and many industries.

CIM INSTRUCTIONAL STAFF

Successful implementation of a CIM program is dependent upon facilities, equipment and curriculum design. The quality of program instruction, however, will be in direct proportion to the computer manufacturing knowledge and expertise of the instructors assigned to CIM courses. The ultimate challenge to implement a CIM program will be to hire new staff with the expertise in computer manufacturing and/or provide the training for existing staff to develop that expertise. Continued staff training will be essential to keep pace with the changing technology as new hardware and software is developed and utilized by industry in computer integrated manufacturing.

ADDENDUM

COMPUTER INTEGRATED MANUFACTURING TECHNICIAN
COURSE DESCRIPTIONS

COMPUTER INTEGRATED MANUFACTURING CONCEPTS

This course will define Computer Integrated Manufacturing (CIM) and provide an overview of the application of computer-based automation for manufacturing and processing industries. Presentations will focus on computer controlled modular subsystems for product design, part forming, assembly of parts and subassemblies, inspection of parts and subassemblies, production planning and control, and information and data control. The student will learn how the subsystems are interconnected and the communication requirements to form an "integrated" system. Additional topics covered will include; status of CIM development and application in domestic and foreign manufacturing, and implications of CIM on productivity and quality for U.S. manufacturing.

MANUFACTURING PROCESSES - MACHINING

Processes and principles related to industrial machining to include: milling, turning, grinding, drilling, boring, broaching, and NC machining will be presented in this course. The student will become familiar with the various machine tools, their capabilities and tooling requirements through instructor lectures and demonstrations and practical "hands-on" applications. Metrology and inspection principles and a study of ferrous and non-ferrous materials as they relate to machining processes will also be covered.

MANUFACTURING PROCESSES - WELDING/FABRICATION

A study of metal fabrication and joining processes employed in modern product manufacturing. Processes, equipment, tooling and material requirements for metal shearing, forming, stamping and finishing will be reviewed. Joining of materials to form a part or product incorporates the use of adhesives, fasteners and/or welding. Resistance and fusion welding processes, equipment, tooling and fixtures, and material are examined. Learning activities consist of instructor lecture and demonstration and practical application by students in sheetmetal layout and development, metal forming processes and welding processes.

COMPUTER AIDED DESIGN & DRAFTING (CADD)

This course will introduce the student to computer graphics with emphasis in mechanical design and manufacturing. Terminology, principles, hardware and software requirements and applications will be presented. Extensive hands-on experience on an interactive computer graphics system is provided for two-dimensional design and drafting. It is recommended that the student have practical drafting experience or completion of a mechanical drafting course prior to taking this course.

COMPUTER AIDED DESIGN & MANUFACTURING (CAD/CAM)

This course will build upon the knowledge and skills gained in Basic CADD. The student will explore three-dimensional (3-D) constructions, CAD/CAM system peripheral equipment operation and CAM application software. Upon completion of the course, the student will be able to construct 3-D models and perform model editing, use 3-D coordinate system and view independent constructions, and use 3-D models to create 2-D drawings. The student will also know the function and operation of CAD/CAM equipment to include: plotters, digitizers, printers, and modems. An examination will be made of CAM application software packages for numerical control, circuit board design, flat pattern layout and nesting. Prerequisites: Basic CADD

MANUFACTURING PLANNING

Computer Aided Process Planning (CAPP) plays a key role in integrating design and manufacturing functions. In this course, the student will learn the principles of process planning, group technology (similarity of parts) and manufacturing requirements planning (MRP II). The student will become familiar with software and hardware configurations of present day CAPP systems and will make computer applications in process planning utilizing a manufacturing data base. Lab activities will supplement the classroom instruction.

BASIC NUMERICAL CONTROL

A study of Numerical Control (NC) and Computer Numerical Control (CNC) machine operation and programming. Types of coding, feeds and speeds, tool selection, machine controls and NC applications are studied. The student will prepare NC manuscripts and punched tapes which will be run and verified on various 2- and 3-axis NC machines. The student will utilize microcomputer systems for program editing, printing and tape punching. Prerequisite: Manufacturing Processes-Machining

COMPUTER TECHNOLOGY

This course will provide the CIM technician with the computer skills and knowledge for operation of computers and systems utilizing application software and to manage the transfer and integration of data from the manufacturing data base to and between modular subsystems. The student will develop skill and knowledge of computer operation and operating software as it relates to data storage and retrieval and data base management. An examination will be made of computer hardware to include; the central processing unit (CPU), memory elements, and I/O operation; hardware and software requirements of system interfacing and networking (LAN); and high level language requirements for application software.

COMPUTER AIDED MANUFACTURING - MACHINING

A study of computer aided programming and operation of multi-axis CNC machines. A detailed study of the A.P.T. language is made. The student will use CAD/CAM and graphics NC systems to create piece-part geometry, develop cutter location files, post-process to machine language and run and verify programs on the various CNC machines. The student will understand the principles and make applications of distributive numerical control (DNC). Tooling and fixture requirements for automated machining are also covered. Prerequisites: Basic Numerical Control

ROBOTICS & AUTOMATED MATERIAL HANDLING

Industrial robots and automated material handling systems applications and management will be presented. The student will make various applications and program industrial robots that could include the following: assembly of parts, welding and fabrication, part forming, material handling and palletizing, deburring and spray painting. Course instruction will include classification of robots, principles of end-of-arm (EOA) tooling design, economics, social impact of automation, maintenance and safety. A study of computerized systems for material, part and tooling inventory and retrieval for manufacturing will also be covered.

QUALITY AND PROCESS CONTROL

The most fundamental change in manufacturing today is a commitment to product quality. In order to assure product quality, it is necessary to use statistical tools and methods to monitor, control and analyze the manufacturing process. Students will develop a fundamental knowledge of statistical process control (SPC) and make applications that integrate information from the manufacturing data base and employ computer assisted tools and processes. The student will learn inspection methods of parts and subassemblies by computer-controlled sensor systems during the manufacturing process and at the end of the process. Activities will include making simulated applications with a computer aided inspection and reporting system (CAIRS).

FLEXIBLE MANUFACTURING SYSTEMS

A flexible manufacturing system (FMS) is an integrated manufacturing system which controls and performs a process on a family of parts utilizing computer control, flexible workstations, and integrated material handling. A study will be made of flexible systems that perform the functions of assembly, inspection, machining and joining. The component technologies used in FMS will be examined to include: hardware and tooling, computer control and communication, material and part transfer, process control, and inspection and quality assurance. An overview of FMS management for planning, cost justification and human factors will also be presetned. Prerequisite: Computer Technology and Computer Aided Manufacturing-Machining

MANUFACTURING CONTROL

The modern manufacturing plant must adopt "just-in-time" (JIT) concepts to reduce inventories of materials and parts in process, resulting in increased productivity and reduced product cost. Manufacturing engineers and technicians are responsible for scheduling and routing materials, tools and parts for all shop floor production activities employing methods that support JIT manufacturing. The student will learn just-in-time concepts and use the computer to make simulated applications of production control in a JIT environment. The manufacturing data base will provide information for material requirements planning (MRP) and scheduling of tooling and parts.

COMPUTER INTEGRATED MANUFACTURING PROBLEMS

The student will utilize CIM techniques to analyze and propose solutions to actual or simulated manufacturing problems. Individuals or students working in teams will select, plan and develop a project proposal which will incorporate application and integration of a minimum of two CIM subsystems to manufacture or process a part or product. Problem solutions will require gathering and developing of data, planning and scheduling a process, a quality and process control plan, hardware and software engineering, actual or simulated application and a project report. Prerequisites: Flexible Manufacturing Systems